

REMARKS:

- 1) Referring to item 10) of the Office Action Summary, the Examiner has x-marked neither box 10)a) nor box 10)b) to indicate whether the drawings have been accepted or objected to. As no detailed objection has been set forth, please confirm that the drawings have been accepted.
- 2) The Examiner's attention is directed to applicants' second Information Disclosure Statement being filed together with the present Response. Please consider the IDS, and return an initialed, signed and dated acknowledgment copy of the IDS Form PTO-1449 of November 7, 2005.
- 3) A few editorial corrections and clarifications have been made in the specification, without introducing any new matter. Entry of the amendments is respectfully requested.
- 4) The claims have been amended as follows.

Independent claim 1 has been amended to restrict the barrier layer to an i-type semiconductor barrier layer, as supported in the original disclosure at page 6 line 12 to page 7 line 3 (especially page 6 lines 21 to 22); page 11 lines 7 to 10; page 26 lines 26 to 28; page 30 lines 14 to 15 and 25 to 26; etc. Thus, this amendment does not introduce any new matter.

New claims 23 to 25 have been added, to recite further features disclosed in original drawing Figure 10 as well as the

corresponding written description thereof (page 17 lines 6 to 14). Thus, the new claims do not introduce any new matter.

Entry and consideration of the claim amendment and the new claims are respectfully requested.

- 5) After the present amendment, claims 1, 3 to 6, 11 to 13 and 23 to 25 read on the elected species of Fig. 10. Claims 2, 7 to 10, 14 and 15 remain withdrawn. In the invent a generic claim is ultimately found allowable, the Examiner is respectfully requested to rejoin, consider and allow the dependent withdrawn claims 2, 7 to 10, 14 and 15.
- 6) Before particularly addressing the rejections, and comparing the claimed features of the invention to the disclosures of the prior art, the invention will first be discussed in general terms to provide a background.

The present invention is directed to a light emitting device of a group II-VI compound semiconductor, and especially including ZnSe based semiconductor material. The device includes an active layer between an n-type cladding layer and a p-type cladding layer, and further comprises a semiconductor barrier layer between the active layer and the p-type cladding layer. This barrier layer has a band gap larger than the band gap of the p-type cladding layer. With such an arrangement and relatively larger band gap of the barrier layer compared to the p-type cladding layer, the barrier layer supplements the effectiveness of the cladding layer. Particularly, the barrier layer suppresses leakage of electrons from the active layer through the

barrier layer to the p-type cladding layer. On the other hand, holes supplied from the p-type cladding layer are not significantly hindered or suppressed from migrating to the active layer. See the present specification at page 5 line 9 to page 6 line 11, as well as Fig. 11 and the description thereof at page 17 lines 15 to 22.

According to the present amendment, the barrier layer has been limited to an i-type semiconductor barrier layer, i.e. such a layer that is undoped with an impurity and thus of intrinsic type. In this regard, see the original specification at page 6 lines 21 to 22, page 11 lines 7 to 10, page 26 lines 26 to 28, page 30 lines 14 to 15 and 25 to 26, etc. This is a significant feature of the invention and achieves improved device characteristics for the following reasons.

If the barrier layer is doped with p-type impurities, i.e. to be prepared as a p-type semiconductor barrier layer, then the concentration of point defects caused by the impurities is increased in the semiconductor material of the barrier layer. If such a semiconductor layer (having such a high concentration of point defects due to the doping with p-type impurities) is placed adjacent to an active layer, then the light emission efficiency of the semiconductor light emitting device will be decreased, as follows. First, the electrons injected into the active layer from the n-type cladding layer will leak into the p-type barrier layer and/or P-type cladding layer, where the electrons will then be captured in a defect level of the p-type material due to tunneling phenomena. Secondly, the p-type impurities (e.g. nitrogen) of high concentration in the p-type

barrier layer will diffuse into the active layer and thereby decrease or impair the crystallinity of the active layer. Thereby, the active layer becomes less efficient in light emission.

In comparison to the above situation of a p-type barrier layer, the inventive provision of an i-type barrier layer undoped with impurities is able to avoid the above mentioned problems, and thus achieves a comparatively higher or increased light emission efficiency.

The prior art does not disclose and would not have suggested a light emitting device of a group II-VI compound semiconductor having the device structure as presently claimed, especially including an i-type barrier layer between a p-type cladding layer and an active layer. To the contrary, in general, the references do not relate to group II-VI compound semiconductor devices but rather group III-V compound semiconductor devices, and the devices disclosed by the references do not include any barrier layer or do not include an i-type barrier layer but rather a p-type barrier layer or confinement superlattice structure.

- 7) Referring to section 5 on pages 2 to 3 of the Office Action, the rejection of claim 1 as anticipated by US Patent 5,747,827 (Duggan et al.) is respectfully traversed.

Present independent claim 1 requires an i-type semiconductor barrier layer provided between the active layer and the p-type cladding layer of the device, wherein the i-type semiconductor barrier layer has a band gap larger than that of the p-type

cladding layer. Duggan et al. do not disclose such a barrier layer.

The Examiner has referred to the region 13 of Fig. 7 as corresponding to the present barrier layer. However, region 13 is actually a multi-layer superlattice structure to produce a carrier confinement barrier (see col. 6 lines 16 to 52 and col. 8 lines 27 to 43). As shown in Fig. 7 (also see Figs. 6, 8 to 10, 29 to 32), the superlattice structure 13 with its alternating layers consequently also produces a succession of alternating larger and smaller band gaps forming quantum wells therebetween with a miniband for hole transport formed by doping (col. 4 lines 28 to 33, col. 8 lines 5 to 43, col. 12 lines 12 to 51, etc.).

Thus, in the Duggan et al. structure, there is not a clear or consistent band gap larger than the band gap of the p-type cladding layer (4, 20). More importantly, the superlattice region or confinement region can only carry out its intended effect as a multi-layered region, which does not correspond to or suggest a barrier layer as presently claimed. Still further, the superlattice region 13 according to Duggan et al. is not an i-type layer, but rather a doped region, and especially a p-type doped region (see col. 4 line 28 to 33, col. 10 line 64 to col. 11 line 59, etc.).

The actual layered structures of the physical devices are shown, for example, in Figs. 22 and 23 of Duggan et al. Those actual layered structures include a p-typed doped superlattice carrier confinement barrier region 58 between a p-type cladding layer 64 and an active layer 62 (see Fig. 23 and col. 10 line 64 to col. 11 line 16). Such a p-type doped barrier region does not

correspond to and would not have suggested the presently claimed i-type barrier layer.

For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claim 1 as anticipated by Duggan et al.

- 8) Referring to section 6 on page 3 of the Office Action, the rejection of claims 1 and 12 as anticipated by US Patent 6,555,403 (Domen et al.) is respectfully traversed.

Significant features of independent claim 1 have been discussed above, and are not disclosed or suggested by Domen et al.

While present claim 1 is directed to a light emitting device based on a group II-VI compound semiconductor, the device according to Domen et al. is based on a group III-V semiconductor (see col. 3 lines 47 and 67, col. 4, line 30, col. 16 line 10, col. 53 lines 41 to 45, col. 63 line 27, etc.).

While Domen et al. also mention the existence of group II-VI compound semiconductor light emitting devices in the prior art description (col. 1 line 40), that is merely a background discussion and does not relate to the further device structure teachings of Domen et al. In fact, Domen et al. expressly distinguish and point out differences between group II-VI semiconductor devices and group III-V semiconductor devices, and explain why they are further developing the group III-V semiconductor device rather than (and to the exclusion of) the group II-VI semiconductor device (see col. 1 lines 38 to 67).

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A person of ordinary skill in the art knows, as also expressly discussed by Domen et al., that group III-V semiconductor devices have significantly different requirements, structures, operating characteristics etc. in comparison to group II-VI semiconductor devices, so that the teachings regarding one of these semiconductor device types cannot be directly applied to the other type of semiconductor device. This is expressly evident from the discussion at col. 1 lines 38 to 67 of Domen et al. There would have been no suggestion that the teachings of Domen et al. regarding a barrier layer for a group III-V device would have been applicable to group II-VI devices instead of the specifically disclosed group III-V devices.

Furthermore, even if the barrier layer of the group III-V device according to Domen et al. would have been applied to a group II-VI device as asserted by the Examiner, the present claimed feature of an i-type barrier layer would not have been provided or suggested. Particularly, the barrier layer according to Domen et al. is a p-type doped barrier layer (col. 53 lines 62 to 67).

For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1 and 12 as anticipated by Domen et al.

- 9) Referring to section 8 on pages 3 to 4 of the Office Action, the rejection of claims 1, 3 and 4 as obvious over US Patent 6,870,178 (Asryan et al.) in view of Domen et al. is respectfully traversed.

Contrary to the present invention, and as acknowledged by the Examiner, Asryan et al. do not disclose a light emitting device based on a group II-VI compound semiconductor, but rather expressly disclose only group III-V semiconductor devices (col. 4 line 57, col. 12 lines 55 to 60, Table 1 in col. 13, Table 3 in col. 16, etc.

In this regard, the Examiner has referred to Domen et al. for allegedly teaching the group II-VI semiconductor device as an equivalent replacement or alternative for the group III-V device. However, as discussed above, Domen et al. merely refer to the conventional existence of group II-VI semiconductor devices, but do not provide any suggestion that a barrier layer as disclosed by Domen et al. and Asryan et al. for a group III-V device would have been suitable for a group II-VI device. To the contrary, based on the distinguishing discussion between these types of devices provided by Domen et al. (col. 1 lines 38 to 67), a person of ordinary skill in the art would **NOT** have found any suggestion or motivation to try to modify the teachings of the group III-V devices to be incorporated into a group II-VI device.

Also, even if these teachings would have been modified and combined in such a manner (driven only by hindsight recognition from the present application), the barrier layer would have been suggested to have a p-type doping, for example, as taught by Domen et al. (blocking layer 626, col. 53 lines 62 to 67). Thus, an i-type barrier layer in the presently claimed structure would not have been suggested.

For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1, 3 and 4 as obvious over Asryan et al. in view of Domen et al.

- 10) Referring to section 9 on pages 4 to 5 of the Office Action, the rejection of claims 5 and 6 as obvious over Domen et al. in view of US Patent 5,539,239 (Kawazu et al.) is respectfully traversed. These claims depend from claim 1, which has been discussed above in comparison to Domen et al. The Examiner further refers to Kawazu et al. for a disclosure of Zn, Mg or Be dopant species for p-type conductivity doping.

Regarding present claim 5 depending from claim 1, such an asserted suggestion of a p-type doped barrier layer would have been directly contrary to the presently claimed i-type barrier layer based on a group II-VI semiconductor comprising Be. Also, such a suggestion also would not have overcome the shortcomings of Domen et al. discussed above to have provided a suggestion toward the features of present independent claim 1.

Next, the Examiner's assertion of obviousness of the particular material recited in claim 6 is contrary to the Examiner's assertion of patentable distinction between the several species identified in the earlier species Election Requirement of May 25, 2005 in this application. Namely, in the species Election Requirement, the Examiner asserted that there are patentable distinctions between the several species based on the different materials and arrangements thereof. The Examiner cannot now assert that there is no patentable distinction based on the particular material of the barrier layer. Also, the

present specification demonstrates that this particular material achieves beneficial and advantageous results (see e.g. page 17 line 15 to page 18 line 1).

For these reasons, the Examiner is respectfully requested to withdraw the rejection of claims 5 and 6 as obvious over Domen et al. in view of Kawazu et al.

- 11) Referring to section 10 on pages 5 and 6 of the Office Action, the rejection of claims 1 and 11 as obvious over US Patent 5,299,217 (Migita et al.) in view of Domen et al. is respectfully traversed.

As acknowledged by the Examiner, Migita et al. do not disclose a barrier layer that is arranged between the active layer and the p-type cladding layer and that has a band gap larger than that of the p-type cladding layer. In this regard, the Examiner has referred to Domen et al.

However, as discussed above, Domen et al. disclose a barrier layer only in connection with a group III-V semiconductor device, and do not disclose such a barrier layer or any special features of a group II-VI device. Domen et al. also would not have suggested that such features of a group III-V device would have been applicable to a group II-VI device. To the contrary, a person of ordinary skill in the art would not have expected such a cross-over of features (for example see col. 1 lines 48 to 67 of Domen et al.).

It is significant that Domen et al. teach such a barrier layer only in the context of a group III-V semiconductor device, and Migita et al. on the other hand teach a group II-VI device

that does NOT have such a barrier layer. These are significant teachings that demonstrate the general understanding and ordinary skill in the art. Namely, while a group III-V device may benefit from such a barrier layer (Domen et al.), a group II-VI device was not suggested as having such a barrier layer (Migita et al.).

Moreover, even if the p-type doped barrier layer according to Domen et al. would have been combined into the semiconductor device according to Migita et al., that still would not have suggested the presently claimed i-type barrier layer.

For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1 and 11 as obvious over Migita et al. in view of Domen et al.

12) Referring to section 11 on page 6 of the Office Action, the rejection of claim 13 as obvious over Duggan et al. in view of US Patent 5,475,700 (Iwata) is respectfully traversed. Claim 13 depends from claim 1, which has been discussed above in comparison to Duggan et al. Claim 13 is patentable already due to its dependence. The additional disclosures of Iwata regarding the substrate material would not have overcome the deficiencies of Duggan et al. failing to teach or suggest the invention of present claim 1. The Examiner is respectfully requested to withdraw the rejection of claim 13 as obvious over Duggan et al. in view of Iwata.

13) New claims 23 to 25 have been added. These claims recite additional features of the structural arrangement of the barrier layer, which further distinguish the invention over the prior

art. Particularly, according to claims 23 to 25, the barrier layer is a single monolayer arranged between the p-type cladding layer and the active layer, or the barrier layer is arranged directly on the active layer, or the p-type cladding layer is arranged directly on the barrier layer. Thus, these claims expressly exclude a multi-layer superlattice region, and/or the provision of one or more additional layers between the active layer and barrier layer, or between the barrier layer and the p-type cladding layer.

- 14) Favorable reconsideration and allowance of the application, including all present claims 1 to 15 and 23 to 25, are respectfully requested.

Respectfully submitted,
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Applicant

WFF:kd:he/4685
Enclosures:
Transmittal Cover Sheet
Term Extension
Form PTO-2038
IDS, Form PTO-1449
2 references
2 English abstracts
copy and translation of JP Office Action

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